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Abstract: The soy expansion model in Argentina generates structural changes in traditional lifestyles that can be associated with different biophysical and socio-economic impacts. To explore this issue, we apply an innovative method for integrated assessment - the Multi Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) framework - to characterize two communities in the Chaco Region, Province of Formosa, North of Argentina. These communities have recently experienced the expansion of soy production, altering their economic activity, energy consumption patterns, land use, and human time allocation. The integrated characterization presented in the paper illustrates the differences (biophysical, socio-economic, and historical) between the two communities that can be associated with different responses. The analysis of the factors behind these differences has important policy implications for the sustainable development of local communities in the area.

Key words: Societal metabolism, soy expansion, Chaco, biophysical accounting, rural development, multi-scale integrated analysis

Códigos JEL: D13, J22, O13, O44, Q12, Q57

1. Introduction

Agriculture is a very important sector for Argentina, accounting for around 10% of GDP and approximately 60% of exports (CIA, 2009; FAO, 2010). In terms of employment, the agricultural sector only employs 1% of the working population directly, and around 37% indirectly (AAPRESID, 2008), showing a high level of capitalization compared to other countries in the region (Arizpe et al., 2011). The sector has been undergoing major changes over the last decades related to the expansion of soy.

The model of the soy expansion currently present in Argentina and Brazil implies boosting consumption of different inputs such as machinery, oil, fertilizers and transgenic seeds (Pengue, 2005). Associated changes in land use imply impacts in socio-cultural lifestyles and biodiversity, and pose a threat to food and energy sovereignty (Altieri, 2009).

The area under soy cultivation in Argentina has increased from 6.9 million hectares (Mha) in the 1990s to 16.6 Mha in 2008 (Tomei and Upham, 2009). The land allocated to soy reached 18 million ha in 2009 (Goldsmith et al. 2004; IADB-Garten Rothkopf 2007; Mathews and Goldsztein, 2009). This expansion of arable land has meant that since the introduction of genetically modified soy in 1996, the country has tripled soy production, with an average of 40 million tons of grain in 2008. This was also achieved by increasing yields, from 2,105 kg per hectare in 1996 to 2,826 kg in 2008 (Negri, 2008). Expansion of agricultural area for soy is increasing deforestation and habitat loss during the last century (MSyA and UNEP, 2004; Zak et al., 2008). Argentina and Brazil produce approximately 90 percent of world soy supplies (Mathews and Goldsztein, 2009).

The production of soybeans became completely transgenic in Argentina in 2008. This fast expansion in GM soy resulted in several (positive and negative) impacts such as increasing yields, reduction of farm jobs, increasing monetary flows associated with crop production, increasing pressure on traditional 'marginal' and non-colonized areas, forest clearings, biodiversity losses, carbon releases from both soil and biomass stocks, loss of traditional, mixed agricultural systems and a decline in agricultural diversity, among others (Qaim and Traxler, 2005; Morello and et al., 2006; Monti, 2008a; Monti 2008b; Zak et al., 2008; Tomei and Upham, 2009; Pengue, 2009b).

Recent agricultural expansion is largely driven by modern agribusiness companies oriented to the global market of grains (e.g. soybean). Agribusiness companies profit from economies of scale, administrate very large properties, and aim to put into production all profitable land in order to maximize revenue (Grau and Aide, 2008). The main producers are large-scale companies with multinational, corporate connections (e.g. Cargill, Bunge and Louis Dreyfus) joined by organizations with large financial and technological capabilities (sowing poolsi). The expansion of this crop is supported by government inaction that assumes that large-scale soy mono-crops can be sustainable (Garcia and Arizpe, 2010). At the moment, however, there is no large-scale national policy or plan for guaranteeing the long term sustainability of agriculture within which the expansion of soy may be regulated. In this situation the markets is determining the direction of agricultural development pushing for intensification and export, which has increased the sector's vulnerability to fluctuations in external markets (Tomei and Upham, 2009).

At the regional scale, the main areas under transformation in the country are the Pampas and the Chaco region in the North of Argentina (Pengue, 2009a). Recent processes of rapid deforestation have been described in the Chaco forest in Bolivia, Paraguay and Argentina (Zak et al., 2004; Grau et al., 2005; Boletta et al., 2006; Gasparri and Grau, 2009). Waterway Paraná Paraguay promotes agricultural expansion due to irrigation potential and facilitates the expansion of the soy model to the north of the country (Pengue, 2009a). At the present time an agricultural pressure exists in the Chaco Region where our case studies are located. There is a high demand for new land for soy production that implies a major change in production systems. This change is characterized by technology to intensify production and the adoption of new economic, productive, financial and cultural models that are not characteristic of this region (Pengue, 2005). This expansion has led to a rise in the number of conflicts in the North of Argentina, mainly in poor communities, and due to limited access to land (EPRASOL, 2008). It has also contributed to deforestation, displacement of peasants and farmers, increased demands on water, soil degradation and pollution.

The aim of this article is to characterize and analyze the metabolic pattern – an integrated characterization of flows (monetary and biophysical flows) in term of intensity (per hour of human activity) and in terms of density (per hectare of land use) - of two rural communities, described at the local scale within the context of soy expansion to new areas in North Argentina. The quantitative information is obtained by applying the Multi Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) framework. The resulting integrated characterization is used to individuate relevant changes experienced by the two communities because of the soy expansion, and to study the differences between the two communities due to their distinct responses.

The structure of the rest of the paper is as follows. Section 2 presents the data, methods and area of study. Then main results are shown in Section 3, which are discussed in Section 4. Section 5 offers some concluding remarks.

2. Data and Methods, theoretical framework and Area of Study

In this section we describe the study area, the methodology employed for carrying out the biophysical analysis of societal metabolism and the main variables employed.

2.1. Data and Methods

The research was carried out in four phases: i) an extensive literature review on social, economic, environmental and political aspects associated to soy cultivations at the regional and global scale; ii) tailoring MuSIASEM to the local reality; iii) fieldwork for gathering data (between September 2008 and March 2009); and iv) data integration and analysis by applying the MuSIASEM approach. The two communities are located at the East of Formosa's province in the North of Argentina.

2.1.1. Data collection

The socio-economic, cultural, territorial and agricultural data come from the databases of the Ministry of Finance, Ministry of Agriculture, National Institute of Statistics, and the Province of Formosa. Existing maps were complemented with participatory mapping for the area under study. Due to the lack of information at the local level, questionnaires and in-depth interviews were used to complement the available data when needed. The software used to compile and analyse information was Excel 2003 for data organisation, SPSS for statistical analysis and ArcView 9.2 and Google Earth for GIS analysis. The numbers of questionnaires applied are 26 out of 71 households in Tacaaglé, and 43 out of 446 households in la Primavera. The questionnaires were completed in the presence of the interviewer. The in-depth interviews were the same number as questionnaires and lasted about 3 hour. Demographic data were collected distinguishing five age groups (<5; 6-11; 12-17; 18-65; >65) and gender (male / female). Existing official population data came from the National Census of Population and Housing in Argentina (INDEC, 2001). The census only offered figures at the municipal level, combining rural and urban population corresponding to the municipalities of Misión Tacaagle (2,034 inhabitants in total, including the two rural communities "25 de Mayo" and Carpintería) and Laguna Blanca (6,508 inhabitants, including also the indigenous community La Primavera).

Since the census did not give information at the community level, we had to estimate population. In the case of La Primavera, we followed Iñigo (2008) who estimates 800 families and 3,800 people - based on interviews carried out in 2005 (Iñigo, 2008). Recent studies increase this number up to the range between 4600-5000 people. In the case of Tacaagle, for the communities of Carpintería and 25 de Mayo, data from the Peasants Movement in Formosa (MOCAFOR) survey and the Social Agricultural Program indicated a population size between 255 and 284 people (interview data).

The fieldwork had two principal goals: (i) Identification of the case studies, better definition of the sample, as well as identification of both the main conflicts and needs of the communities. (ii) Data gathering in relation to the different dimensions of analysis (economic activity, land use, time use, etc).

To fulfill these two goals an integrated set of research activities were carried out in the 6 months, in which the first author lived in the two communities. These activities can be described using different labels: a) action research (Bryman, 1989), b) participant observation (Rusell, 2000; Bryman, 1989), c) participatory mapping to identify the different land uses associated with the perceptions and narratives of the locals (NOAA, 2009; FIDA,2009), d) time use analysis, following families in their daily activities keeping records in diaries, e) in-depth interviews, semi-structured interviews (Bryan, 2008), and structured interviews (Bryan, 2008).

2.2. The MuSIASEM approach

2.2.1 The conceptual basis of the MuSIASEM

Studying sustainability entails the challenge of how to properly perceive and represent a process which requires the simultaneous adoption of different dimensions and scales of analysis (Giampietro, 2003). For this reason, sustainability analysis requires the integrated use of non-equivalent descriptive domains and non-reducible models that have to be periodically updated and substituted (Giampietro et al., 2006a, 2006b, 2006c). This challenge calls for new conceptual tools of analysis capable of: (i) remaining ‘‘semantically open’’— i.e. to be adjusted to new meanings and tailored on an evolving issue definition and (ii) integrating quantitative descriptions—i.e. non-equivalent accounting systems—by establishing bridges across different dimensions of analysis and scales.

The methodology multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM) has been developed to address such a challenge when characterizing the viability and desirability of patterns of production and consumption of socio-economic systems (Giampietro, 2003; Giampietro and Mayumi 1997; Giampietro and Mayumi 2000a, 2000b). The methodology integrates various theoretical concepts from different fields: (i) non-equilibrium thermodynamics applied to ecological analysis—Odum (1971, 1983, 1996) and Ulanowicz (1986, 1995); (ii) complex systems theory—Kauffmann (1993), Morowitz (1979), Rosen (1958, 2000), and Zipf (1941); and (iii) bioeconomics -- Lotka (1956) and Georgescu-Roegen (1971, 1975). Empirical analyses based on this approach has been conducted at a national level for countries such as Ecuador (Falconí-Benítez 2001), Spain (Ramos-Martin 2001), Vietnam (Ramos-Martin and Giampietro 2005), China (Ramos-Martin et al. 2007), Chile, Brazil and Venezuela (Eisenmenger et al., 2007), the UK (Gasparatos et al., 2009), Romania, Bulgaria, Poland and Hungary (Iorgulescu and Polimeni, 2009), Argentina (Recalde and Ramos-Martin, 2011), but also at the regional level (Ramos-Martin et al., 2009), and at the household/community level (Gomiero and Giampietro 2001). In this work, we build on Gomiero and Giampietro's work, along with Land-Time-Budget Analysis (Pastore et al. 1999; Giampietro 2003; Grünbühel et al., 2003; Grünbühel and Schandl 2005), and compare the societal metabolism of two rural communities in the North of Argentina, with the main objective of providing sound information that will allow the comparison of various attributes relevant for the sustainability of the models of development. That is, the resulting integrated analysis makes it possible to explore the farming household's interaction with natural resources in order to identify economic and ecological constraints and development opportunities. With this study we want to better understand the ongoing process of soy expansion in the region, and its repercussions in traditional farming practices and standard of living.

A key theoretical concept of the MuSIASEM approach is the incorporation of the flow-fund model proposed by Georgescu- Roegen (1975) for representing, in biophysical terms, the socioeconomic process of production and consumption of goods and services. The flow-fund model makes it possible to carry out quantitative analysis of complex systems organized across different hierarchical levels and scales. In fact, following Giampietro et al. (2011) we can say that according to the chosen representation of the process flow coordinates are elements that enter but do not exit the production process (e.g. an input used in production) – in the time horizon of the analysis - or, conversely, elements that exit without having entered the process (e.g., a new product). Flow coordinates refer to matter and energy in situ, controlled matter and energy, and dissipated matter and energy. Fund coordinates (capital, labour and Ricardian land) are agents that - in the chosen time horizon of the analysis - enter and exit the process, transforming input flows into output flows. Put in another way, the identity of the fund elements remains the same during the analysis. Fund elements require a given overhead for their own maintenance and reproduction and do entail a constraint on the rate of their associated flows. That is we can define a range of value for the pace of conversion of the flows they control.

In this paper we focus on two fund elements:

(i) land – this makes it possible to study the interface between the colonized land (land uses whose characteristics depend on human agency) and non-colonized land (land covers whose characteristics depend on the identity of local ecosystems); and

(ii) human time – this makes it possible to study structural (demographic) and functional (socio-economic) changes in the allocation of human activity within the communities;

and two main flow elements:

(i) monetary flow – this makes it possible to interface the biophysical analysis with economic analysis;

(ii) biomass flows – this makes it possible to interface the biophysical analysis with both economic and agronomic analysis;

It should be noted that in this paper we do not include other biophysical flows (energy, water, and other key materials – e.g. soil erosion, cement for construction) in the characterization of the metabolic pattern, since at the chosen level of analysis – the community level – they do not result relevant for the purpose of our analysis.

2.2.2 The categories used to characterize the fund element land

In the case of land use we started with a study of land use changes made by the Ministry of Forests (Naumann and Madariaga, 2003) with data from fieldwork activity (2008-2009). We use the categories presented in Giampietro (2003):

TAL = LU_{NC} + LU_{SC} + LU_{COL}
NCL= National Park, RAMSAR sites (wetlands) and water bodies
COL = LU_{agr} + LU_{liv} + LU_{infr} + others
LU_{SC} =LU semicolonized

where

TAL stands for Total Available Land (or availability) which includes both colonized and non-colonized , and it conforms the land budget for the system analyzed
NCL stands for non-colonized land
COL stands for colonized land, and comprises the various categories of land uses under direct control of humans – e.g. colonized land for agriculture (agr), livestock (liv), infrastructure (infr), and others. COL for Colonized land (splitting into LUi), $\sum$LUi = COL
LU_{SC}, stands for semi-colonized land. Examples are land for hunting or gathering.

LU_{agr} can also be split in two subcategories: subsistence agriculture and industrial agriculture that is focused on expansion of soybean or cotton cultivation. LU_{infr} is mainly land use for the dwelling and includes the constructed area as well as the surrounding area for keeping poultry and pigs.

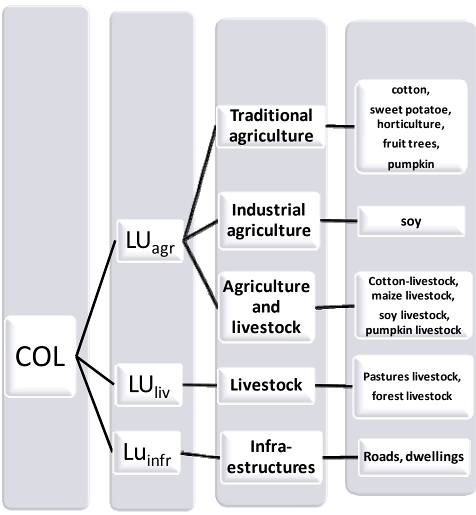


Figure 1. Taxonomy of categories of land uses within colonized land.

2.2.3 The categories used to characterize the fund element human activity

Regarding human time use we build on previous work to select the set of categories relevant for our study (Giampietro, 2003; Pastore et al. 1999). Total Human Activity (THA) is the total human time a society has available for conducting all the activities, and is measured in hours. It equals population times 8,760 hours. THA can be split in different sub-categories according to the specific activity:

• Time for physiological activities (Physiological Overhead) HA_{PO}, referring to the accumulated number of hours for sleeping, eating and personal care.
• Time spent on unpaid work (HA_{UW}), including the number of hours used in maintaining the household, such as cooking, cleaning, going to the store, childcare.
• Time allocated to paid work activities (HA_{PW}), i.e., the number of hours that are related to the market.
• Time for mobility and transportation (HA_{TR})
• Time for leisure and recreation activities (HA_{LE})

Therefore:
$THA= HA_{PO}+ HA_{UW}+ HA_{PW}+ HA_{TR}+ HA_{LE}$

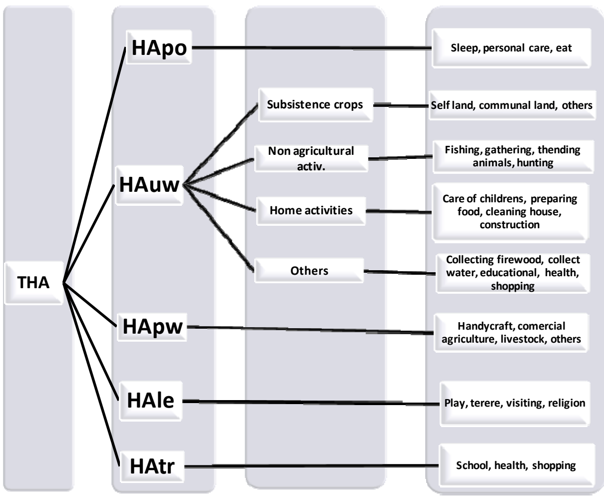


Figure 2. Taxonomy of categories of time uses

2.2.4 The multi-scale view of the metabolic pattern

By implementing the flow-fund model, within the MuSIASEM approach it becomes possible to develop a quantitative accounting of flows across different hierarchical levels and scales (Giampietro et al. 2000; Pastore et al. 2000; Gomiero and Giampietro, 2001; Giampietro, 2003; Giampietro et al. 2011). In particular, when dealing with the analysis of farming systems we can define “metabolic units” [autopoietic systems capable of reproducing themselves when operating in favourable boundary conditions – Giampietro et al. 2011] at different hierarchical levels: households, communities, municipalities. Figure 3 shows the multi-scale nature of the accounting associated with this analysis of metabolic pattern. In this paper we have chosen as focal level the community level – which is level n in the figure applied to our case study. The characteristics of the community are affected by upper level constraints (the characteristics of the municipality to which the community belongs – level n+1), and its behaviour is the result of the initiating conditions determined at the lower level. In particular, the characteristics of a community are determined by the household typologies (defined at the level n-2) and the profile of distribution of instances of these typologies within the community.

Because of this choice of focal hierarchical level, this paper focuses on the main differences in the pattern of land uses and the pattern of human activity, expressed at the community level, between the two communities analysed, La Primavera (Potae Napocna Navogoh) and Tacaagle. In a forthcoming paper we provide the same type of analysis carried out at the level of lower level components (i.e. households) of those communities.

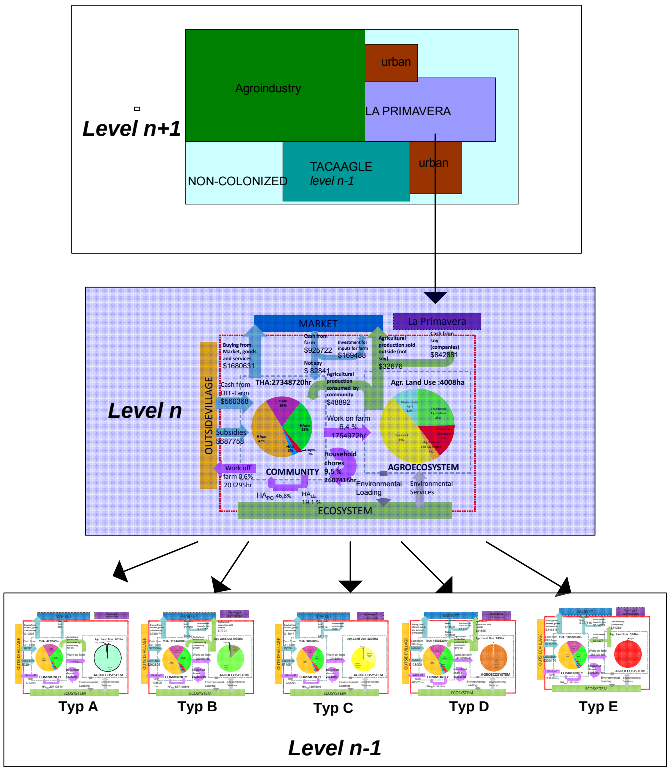
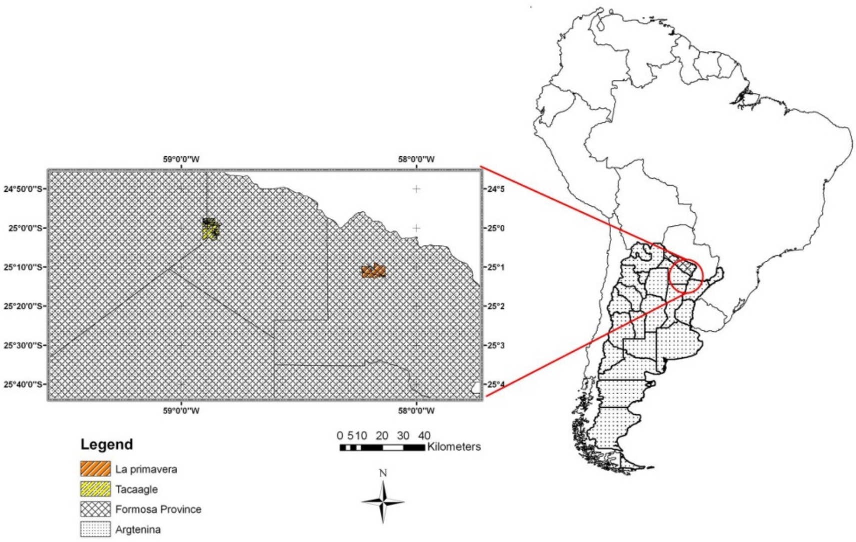


Figure 3. Multi-scale and our focal level at the community level

2.3 Area of study

Case study research entails the detailed examination of one or a small number of 'cases'. Since our unit of analysis is the community level, in this study,we consider two rural communities that share similar problems such as the expansion of soy cultivation, and similar ecological conditions. A key difference however is the history and culture of the population. Tacaagle, that is located in the Pilaga Department in the Formosa Province, is populated mostly by non-indigenous people immigrated mainly from Argentina and Paraguay, whereas La Primavera "Potae Napocna" located in Pilcomayo Department has an indigenousii population, called Qom, although their popular name is Toba. Both communities are located in the Formosa Province in Argentina, and each of them has a surface area of approximately 5,500 hectares.

The Tacaagle's community is composed of two rural communities ("25 de Mayo" and Carpinteria) comprising 71 households. La Primavera "Potae Napocna" has Qom population and consists of 446 households.



Source: own elaboration.

Figure 4. Map of the study area

The main economic activities of the Province of Formosa are related to food production and processing industries. The main crops are cotton, soybeans, wheat, rice, sunflower, sorghum, corn, and avocado. They also grow fruits, such as citrus, bananas, mangos, and pineapple. Forestry is also of major economic importance, with the main species under exploitation being: red and white quebracho, lapachos guayaibí, algarrobo, guaranine, urunday and rosewood. Apart from that, other relevant economic activities are livestock and bee-keeping, from which organic honey is produced. Finally, some oil extraction occurs in the west of the province (Ministerio del Interior, 2011).

The two case studies are found between the Glens Forest Chaco and the Lower Rio Paraguay. As an example of their ecological value, National Park Rio Pilcomayo (sharing land with La primavera community) hosts 49 species of mammals, 353 species of birds, 28 species of amphibians, 35 species of reptiles and 38 species of fish (Morello and Rodriguez, 2009).

3. Results

In this section we present first the profile of allocation of the fund element land (budget of colonized land across different compartments) and the profile of allocation of the fund element human activity (budget of human activity across different compartments) of the two communities. Then we provide a comparison of the two communities based on an integrated analysis of flow/fund ratios. The different land-time budgets found in the two communities are used to analyze the density (flows per hectare) and the intensity (flows per hour) of monetary and biophysical flows.

Population and land data based on the findings of our surveys are presented in Table 1. The difference in population density is very large, for example in Tacaagle, where most of the inhabitants live in an urbanized setting, whereas in La Primavera the indigenous still consider land and resource management as a part of their life reflecting a deep cultural link with natural ecosystems.

Table 1. Characterization of the communities in terms of people and land.

Communities	No. Inhabitants	No. Household	Total Land (Ha)	Density (pop/100 Ha)
La Primavera	3,122	446	5,186	60
Tacaagle	284	71	5,576	5

Source: own elaboration. Household Survey, 2009

3.1. The pattern of land use at the community level

The characterization of the fund element “land use” in the two communities is carried out using three main categories: (i) colonized land – land under human control in which the density and intensity of biomass flows is determined by human agency (high external input agriculture); (ii) non-colonized land – land covers outside human control in which the density of biomass flows is determined by ecological processes; and (iii) semi-colonized land – land in which human activity does not alter the value of natural processes of production of biomass, based on natural recycling of nutrients (low external input agriculture). Still human agency prevents, in these categories of land use, the expression of the typology of land cover that would be expected in the area without human interference - e.g. use of natural pasture for seasonal feeding livestock. This category of land is characterized for having more biodiversity than colonized land. Non-colonized land also includes areas of rivers and lakes and the forest, even if used for hunting or gathering.

Table 2. Distribution of land use types

Type of LU	Tacaagle (Ha)	%	La primavera (Ha)	%
Colonized	3,961	71	1,722	33
Semi-colonized	1,599	29	1,715	33
Non-Colonized	16	0	1,749	34
Total LU	5,576	100	5,186	100

Source: own elaboration.

3.1.1. Characterizing Land use in Tacaagle’s community across hierarchical levels

The profile of distribution of land uses in Tacaagle’s community is shown in Fig. 5. This characterization is based on the selection of categories defined in Table 2. In this view we can individuates a small amount of non-colonized land corresponding to the river “Riacho porteño” and the riparian vegetation.

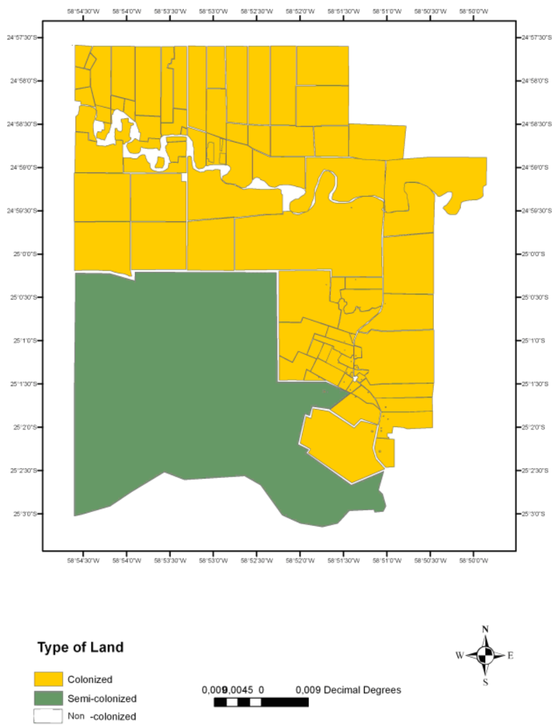


Figure 5.Distribution of land use in Tacaagle's community

A more articulated analysis can be obtained by adding additional categories of land uses defined within the category of colonized land. Using the definition of colonized land given above, we can define these categories according to the main activity performed there, either related to agriculture or livestock. The list of categories used for this more detailed analysis of the profile of land uses within colonized land is given in Figure 1.

A detailed information about the main crops and plots of land characterized using this taxonomy was obtained through ethno-cartography and cross-referencing with GPS. This information was merged with Google Earth images in order to define the extent of plots (locally called chacras[iii]) with more precision.

Table 3 presents the dendrogram of land uses according to the different categories determined by the activities performed. We start with the total available land (TAL), which is split into colonized land (COL) - the vast majority - and non-colonized land (NCL) – mainly riparian. Colonized land is then split into the main activities, agriculture (37 %), livestock (62%) and infrastructure (1%). The main category is clearly livestock, followed by the combined use for agriculture and livestock. We already see that soy is the main cultivar, higher than cotton (another cash crop) and horticulture and fruits (subsistence). The non-colonized land refers to the river (Riacho Porteño).

The spatial distribution of actual land uses over the taxonomy of categories introduced in Table 3 is shown in Fig. 6. The map shows small-size producers[iv] have a greater diversity of crops, and they also share plots[v] between households. The medium-size producers generally cultivated a particular crop depending on regional market demand. And finally the large-size producers are distributed in areas closer to the semi-colonized land. It is important to observe that both small and large-size producers use the semi-colonized land for extensive livestock. In general, this is private land where the owner leases access for grazing to livestock owners.

Table 3 Dendrogram of land use in Tacaagle

		Land Use Tacaagle	Ha		Type	Ha	Categories	Ha
TAL	5,576	COL	5,560	LU_{agr}	Traditional Agriculture	673	cotton	285
							sweet potato	55
							horticulture, fruit trees	262
							maize	9
							maize, cotton	41
							maize, sweet potato	18
							pumpkin	3
					Industrial Agriculture	496	soy	496
					Agriculture and Livestock	874	cotton-livesock	209
							maize-livestock	554
							soy-livestock	99
							pumpkin-livestock	12
				LU_{liv}	Livestock	3,508	pasture-livestock	1,599
							forest-livestock	1,909
				LU_{infr}	Infraestructures	8	roads	7
							dwellings	1
		NCL	16		Water bodies	16	rivers	16

Source: own elaboration

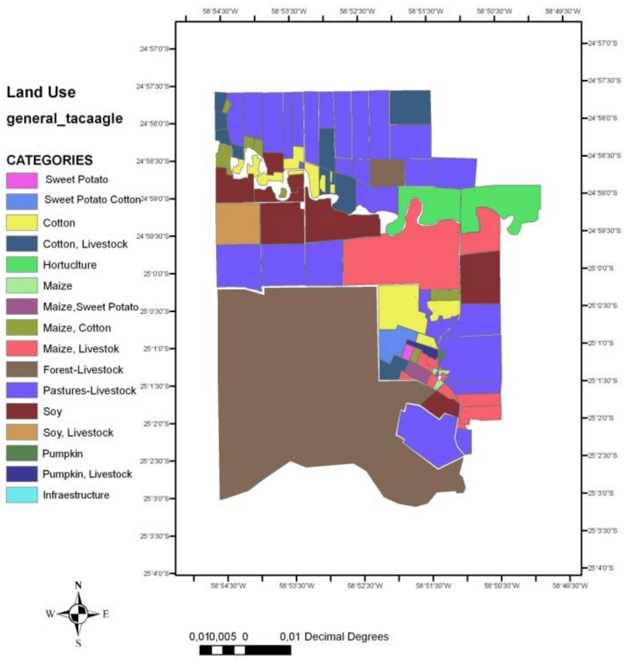


Figure 6 Map of the land uses in Tacaagle's community

3.1.2. Characterizing Land use in La Primavera community across hierarchical levels

The profile of distribution of land uses in La Primavera community is shown in Fig. 7. This characterization is based on the selection of categories defined in Table 2. In this case, non-colonized land consists of a lake and forest land that is currently the focus of a dispute between the community and the Rio Pilcomayo National Park. The community land of Qom population was included in the National Park in 1951 and since the year 2000 they lost use rights to the lake for their livelihood.

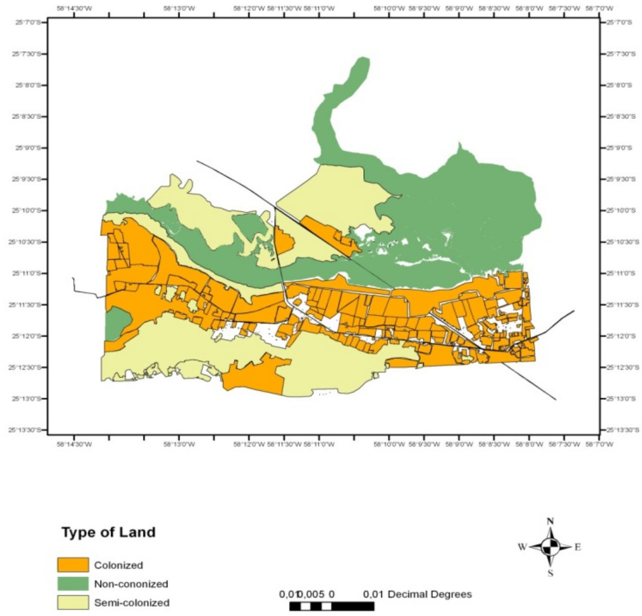


Figure 7. Distribution of land use in La Primavera"Potae Napocna" community

Although having 10% more population than Tacaagle, La Primavera community has a higher proportion of non-colonized land (33.2%) due to the overlap with the national park. The community also has smaller plots of land related to their density.

The list of categories used for this more detailed analysis of the profile of categories of land use within the category colonized land is given in Figure 1.

The dendrogram of land uses according to the different activities performed within colonized land is shown in Table 4. The total non-colonized land (30%) consists of the lake, and other water bodies, as well as wetlands. Colonized land is then split into the main activities, agriculture (30%), livestock (31%) forest (8%) and infrastructure (3%). The main category is agricultural land and livestock, followed by forest. We already see that soy is the main cultivar, higher than cotton and horticulture and fruits for subsistence. Most of the cotton production has been displaced by soy.

The indigenous population does not use the land for industrial agriculture. They generally rent it to non-indigenous producers. However, they take care of crops and livestock.

Table 4 Dendrogram of land use in La Primavera"Potae Napocna"

		Land Use La primavera	Ha		Type	Ha	Categories	Ha
		COL	3,437		Agriculture	995	fruits	51
				LU_{agr}			cotton, maize	350
					Industrial Agriculture	594	soy	594
					Agriculture/livestock	149	cotton, maize, livestock	149
TAL	5,186			LU_{liv}	Livestock	1,809	pasture-livstock	556
							mountain-livestock	1,254
				LU_{infr}	Infraestructures	22	roads	19
							dwellings	4
				LU_{mount}	Forest	461	forest	461
		NLC	1,749		Water bodies	701	lakes	701
					Marsh	1,048	marsh	1,048

The spatial distribution of actual land uses (2008-2009) over the taxonomy of categories introduced in Table 4 is shown in Fig. 8. From this figure we can immediately see that the spatial distribution of the land use is quite different from that found in Tacaagle: there is less crop diversity (agriculture) and a major share of non-colonized land or semi colonized land – i.e. wetlands, lakes and forests. The forest land is important to obtain resources such as food (gathering and hunting), fuels (wood) and water. A large area (rapidly expanding) allocated to soy (10%) can be identified in the middle of the community.

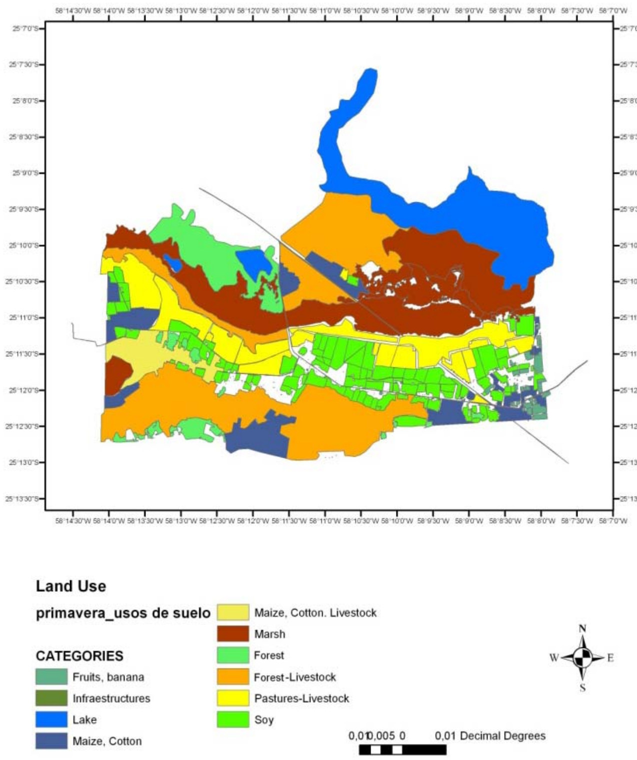


Figure 8. Map of the land uses in La Primavera "Potae Napocna" community.

3.2. The pattern of time use at the community level

The characterization of the fund element "human activity" in the two communities is carried out using the taxonomy of categories defined in section 2.3.3. In addition to this classification, the information obtained via interviews, at the household level, made it possible to distinguishing the different profile of human time allocation of men and women.

The data are illustrated in Fig. 9 for both communities. As expected, the largest fraction of human time is spent in Physiological Overhead (47%) – sleeping, eating, personal care of each individual during the day - followed by unpaid work time (30%). Within this category women not only have household maintenance activities, but also contribute to gathering forest products and other farm activities. With regard to leisure time, the assessment includes resting time (e.g. naps after lunch) and cultural activities (e.g. terere or mate)vi. As shown in figure 9, the two communities generally spend little time in paid work (8%) mostly because they get food from their own chacras or government support. Very little time is spent for transport (3%) although it is important for rural societies such as these where people do not live in nuclear villages[vii].

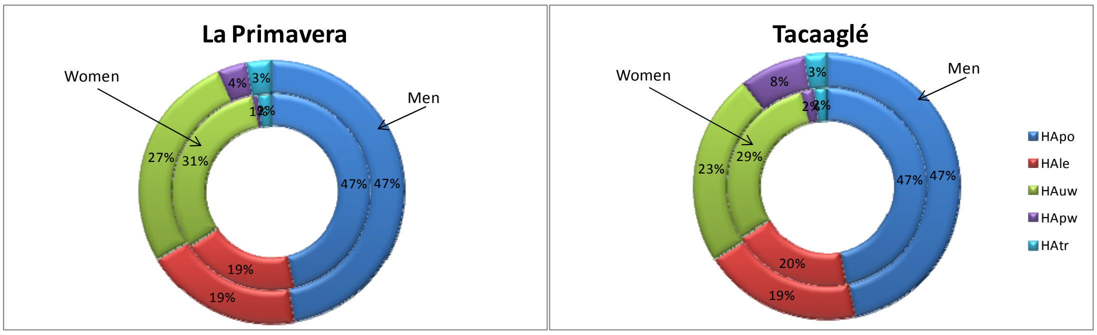


Figure 9. Distribution of the THA by classification and gender.

In Table 5 we can identify the different categories of human activities used to study time allocation (measured in hours/years) and their share (%). From this comparison we can see that the amount of human time allocated to physiological overhead is almost the same, with a small difference in sleeping and eating between the two communities.

Human activity in unpaid work includes hours dedicated to the following tasks: subsistence crops (4%); non agricultural activities (2%); household activities (10%)[viii]; and other activities (11%). In terms of unpaid work, some activities such as hunting and gathering, and collection of firewood and water are more important in La Primavera community.

Human activity in the paid work category reveals interesting differences. La Primavera shows a lower proportion of time devoted to paid work, however commercial agriculture and handicrafts are the main sources of paid work there. In contrast, Tacaagle doubles the amount of time allocated to commercial agriculture, more than doubles that in livestock and practices no handicrafts at all.

Table 5. A comparison of the profile of Time Use in the two communities

				La primavera		Tacaagle	
			Activities	Hr/year	%	Hr/year	%
	HA_{po}		Sleep	9,865,871	36.1	856,071	34.4
			Personal care	1,446,098	5.3	147,197	5.9
			Eat	1,488,607	5.4	159,932	6.4
				12,800,576	46.8	1,163,200	46.8
	HA_{uw}	Subsistence crops	Self-land (Chacra)	814,975	3.0	79,512	3.2
			Communal Land	481,151	1.8	10,238	0.4
			Others	14,417	0.1	0	0.0
				1,310,543	4.8	89,750	3.6
		Non-agriculture activities	Fishing	64,616	0.2	2,851	0.1
			Food gathering	74,038	0.3	2,851	0.1
			Small farm/tending animals	196,499	0.7	16,797	0.7
			livestock/tending animals	36,466	0.1	28,302	1.1
			Hunting	214,154	0.8	3,628	0.1
				585,772	2.1	54,429	2.2
		Home activities	care of children	2,213,812	8.1	207,550	8.3
THA			Preparing food	226,922	0.8	33,171	1.3
			Cleaning the house	102,091	0.4	15,852	0.6
			Construction	64,590	0.2	3,672	0.1
				2,607,416	9.5	260,245	10.5
		Others	Collecting firewood	399,698	1.5	12,279	0.5
			Collecting water	435,742	1.6	5,701	0.2
			Educational	1,582,708	5.8	179,120	7.2
			Health	304,058	1.1	22,298	0.9
			Communal gatherings	309,768	1.1	10,753	0.4
			buying/shopping	260,093	1.0	22,637	0.9
				3,292,066	12.0	252,788	10.2
				7,795,797	28.5	657,212	26.4
			handicraft	138,756	0.5	0	0.0
	HA_{pw}		Comercial agriculture	391,694	1.4	71,854	2.9
			livestock	52,735	0.2	41,395	1.7
			others	203,295	0.7	15,611	0.6
				786,480	2.9	128,860	5.2
	HA_{le}		Play	2,622,388	9.6	246,430	9.9
			Terere	784,321	2.9	72,562	2.9
			friend/familiar visiting	826,747	3.0	78,263	3.1
			Religious activities	985,693	3.6	81,709	3.3
				5,219,150	19.1	478,964	19.3
	HA_{tr}		buying/shopping	231,113	0.8	20,214	0.8
			Health	327,289	1.2	21,509	0.9
			School	76,918	0.3	8,552	0.3
			others	111,398	0.4	9,329	0.4
				746,718	2.7	59,605	2.4

3.3. The land - time budget analysis (LTB): the integrated analysis of the two fund elements “land uses” and “human activities”

The LTB analysis integrates the previous analyses of time and land aggregating the information at a given hierarchical levels: either the land-time budget of a household (at the level n-1) or the land-time budget of the community (at the level n). The analysis of land-time budget can be integrated with an analysis of flows – e.g. monetary and food flows – providing useful information for sustainability analysis.

The two fund elements “land use” and “human activity” are essential for the reproduction and operation of rural systems. With the MuSIASEM approach it is possible to study the allocation of these two elements in autopoietic units (households, communities, municipalities, countrie) across different hierarchical levels and scales. This result can be obtained by combining the two dendrograms of split of the fund elements land use, illustrated in Tab. 4 and Tab. 6 with the information about the dendrograms of split of Total Human Activity over the categories shown in Tab.7. In this way it becomes possible to couple the two dendrograms of the distribution of fund elements across levels distributed over the same taxonomy of categories - Giampietro (2003) and Grünbunhel and Schandl (2005) – as illustrated in Fig. 10.

The dendrogram of allocations of hours of human activity starts with Total Human Activity (THA) in the box on the upper left side of Fig. 10. This initial amount of human activity is then divided into “Physiological Overhead” (POHA) and “Human Activity Disposable Fraction” (HADF).

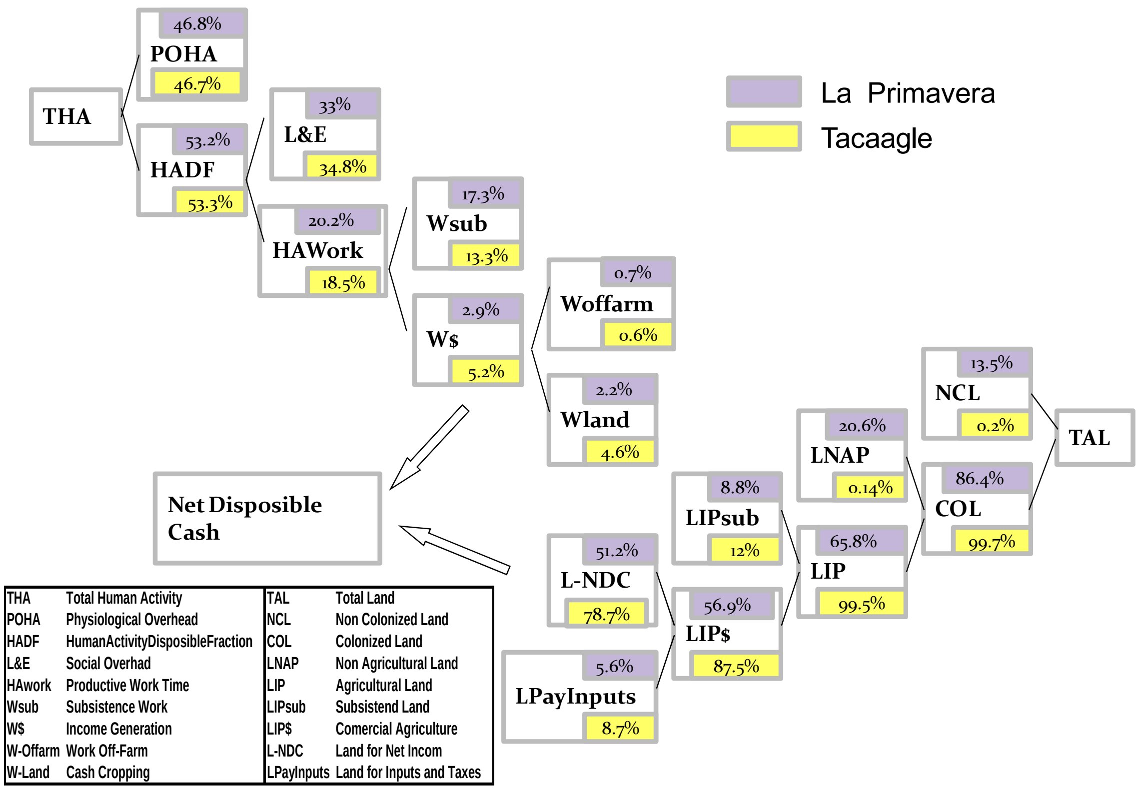
Out of the total amount of hours of “Human Activity Disposable Fraction” (HADF), the society allocates a certain fraction to its own reproduction. This fraction includes leisure, education, social life and events. This fraction of human activity belongs to the category Leisure and Education (L&E), which should be considered as a sort of “societal overhead” on labor time as this amount of hours of human activity are not directly used to perform economically productive activities. The remaining of HADF is included in the category “work time” (HAWork) which is allocated to a number of economic and household activities: off-farm wok (agricultural companies or industries outside the community), cash cropping (harvesting for profits), subsistence farming (agriculture, livestock, hunting and gathering), household chores (all household activities not related to food production).

By using these categories it becomes possible to generate more effective comparison among the communities. For example, La Primavera community shows a higher share of work time even though not necessarily agricultural work. In fact, hunting and gathering are time intensive activities. In general, more work for subsistence is found in La Primavera because of cultural reasons. Giampietro (2003) further divides the category of Work Time into additional categories: (i) work in the household’s own land (W-land); and (ii) off-farm work (W-off farm). In relation to this categorization, Tacaagle community has a larger fraction of human activity dedicated to working the land, which is the main source of income. In terms of land use, this translates into a structure of small and medium-size plots.

The dendrogram of allocations of hectares of colonized land starts with Total Available Land (TAL) in the box on the upper right side. In our accounting system the TAL of the community is defined by the administrative boundaries of the system.

Of the total amount of land that can be used by the community (the total budget), there is a first fraction that is not used productively by the society. This non-colonized land (NCL) can also be considered as the Ecological Overhead of Available Land. This label suggests that a portion of available land should be preserved from human exploitation, because of some sort of social agreement, justified either by the need of conservation, religion taboos, cultural traditions. The remaining land is included in the category of ‘Colonized Land’ (COL), which refers to all land used productively by the society. This category is further subdivided into land not in agricultural production (LNAP) and agricultural land (LIP). Forests provide firewood, construction material, food, and marketable products. Agricultural land (LIP = Land in Production) comprises fields, pasture, fallow land, and gardens. Within agricultural land it is possible to distinguish between land for commercial production (LIP$) and subsistence land (LIPsub). The proportion of the land in the category LIP$ can be further allocated to different categories of land use (and concurrent categories of human activities): for cash crops, productive land used to cover taxes, productive land used to cover technical inputs (self-produced inputs, such as seeds, or purchased inputs, such as fertilizer, tools and machinery). This category makes it possible to individuate a final division in Figure 8 between land that produces net disposable cash (L-NDC) and land that is producing monetary flows needed to pay taxes and inputs (L-pay inputs).

At this point this quantitative information makes it possible to calculate for selected categories both: (i) density of flows per hectare of specific categories of land uses (e.g. food per hectare, added value per hectare); and (ii) intensity of flows per hour in specific categories of human activity (e.g. food per hour of labor, or added value per hour of labor). These values can be used for comparison and to generate benchmarks making possible to assess the performance of rural communities, in relation to different criteria. For example we can calculate the average net production of added value per hour in the category “work in cash crops” and within this category compare the performance of different crops as a source of income. In the same way, we can move the assessment to the whole household, aggregating all the monetary flows entering in the household economy divided by the amount of hours invested in the various categories of human activity associated with generation of cash. The same analysis of individual activities or aggregate performance in relation to relevant flows (monetary or food) can be carried out in relation to the categories of land uses.



THA	Total Human Activity	TAL	Total Land
POHA	Physiological Overhead	NCL	Non Colonized Land
HADF	HumanActivityDisposibleFraction	COL	Colonized Land
L&E	Social Overhad	LNAP	Non Agricultural Land
HAwork	Productive Work Time	LIP	Agricultural Land
Wsub	Subsistence Work	LIPsub	Subsistend Land
W$	Income Generation	LIP$	Comercial Agriculture
W-Offarm	Work Off-Farm	L-NDC	Land for Net Incom
W-Land	Cash Cropping	LPayInputs	Land for Inputs and Taxes

Figure 10. Land Time budget analysis.

3.4. The analysis of flow elements: monetary and food flows

3.4.1. Monetary flows

The accounting of monetary flows has been done using the same taxonomy of categories used for the land-time budget. This choice is required to make it possible to generate two sets of ratios flow/fund elements characterizing the specific metabolic pattern of the two communities.

The monetary flows (US dollars/year) measured in US dollars 2008 are illustrated in Table 6. The data are organized in 4 main categories: (i) total production at the community level: (ii) the fraction of farm production self-consumed by the community; (iii) the fraction of the production sold outside; (iv) flows of subsidies. It should be noted that in this way we are assessing two categories of monetary flows: (i) cash flow; (ii) the economic value of the goods consumed in subsistence (assessed by the quantity consumed time its market price).

By looking at these data we can see that Tacaagle community has a greater share of traditional agriculture, barnyard and livestock, as well as higher farm consumption. La primavera, on the contrary, focuses on industrial agriculture (soy), and an important share of their in income comes from renting land to companies.

Table 6. Monetary Flows in Tacaagle and La Primavera "Potae Napocna"communities.

		Tacaagle total	La primavera total
Trad. Agriculture production	$/Ha	62.5	27.5
Soy production	$/Ha	463.2	1644.7
Llivestock production	$/Ha	23.8	20.6
Barnyard animals production	$/Ha	0.2	0.2
Total Farm production	$/Ha	86.6	48.2
Trad. Agriculture consumed by the community	$/Ha	32.3	8.1
Livestock consumed by the community	$/Ha	11.2	5.9
Barnyard animals consumed by the community	$/Ha	0.3	0.3
Farm prodution consumed by the community	$/Ha	43.8	14.2
Cash out inputs of agriculture	$/Ha	10.6	9.9
Cash out inputs of soy	$/Ha	117.5	226.4
Cash out inputs of livestock	$/Ha	0.2	0.2
Cash out inputs of barnyard animals	$/Ha	0.2	0.1
Total cash out input	$/Ha	21.5	49.3
Agricultural production sold outside	$/Ha	19.6	9.5
Soy production sold outside	$/Ha	345.7	1418.4
Livestock production sold outside	$/Ha	12.3	14.5
Barnyard animals production sold outside	$/Ha	0.2	0.1
Total production sold outside	$/Ha	32.1	269.4
Land Rent to companies	$/Ha	157.9	52.6
Cash out to buy goods and services	$/Ha	104.9	489.0
Buying for the market	$/Ha	32.3	244.6
Work off farm	$/Ha	28.5	163.1
Subsides	$/Ha	1.0	200.1

3.4.2. Food flows

The total crop production in the two communities, estimated for the year 2008, is shown in Table 7. Such estimation has been obtained by combining information gathered via questionnaires to producers, fieldwork records and land use analysis. We have converted crop production into energy units using conversion factors from FAO statistics. This allows us to assess the degree of self-sufficiency by comparing production with consumption.

Regarding endosomatic energy consumption (i.e. food intakes), we base our analysis in the information collected in the questionnaires and through participatory observation. Energy equivalences are calculated again with FAO conversion factors (FAO 2007).

The community of Tacaagle has an average consumption of approximately 1,781 kcal/capita/day from crops. The total protein supply is 25g/capita/day and the fat supply amounts 37g/capita/day. These values come from the consumption of cassava, maize, beans, pepper, pimento, potatoes, pulses, rice, soy oil, spices, sunflower seed oil, sweet potatoes, tomatoes, other vegetables, wheat, starchy roots, peanut, alcoholic beverages, sugar, apples, pineapples, banana, grapefruit, lemons, limes, oranges, mandarins, melon and sugar cane. The non-crop based food supply is approximately

1,004 kcal/cap/day, with 64 g/capita/day of proteins and 71g/capita/day of fat. The main sources being honey, bovine meat, cheese, cream, eggs, freshwater fish, meat other, milk, pork-meat, poultry meat, animal fats.

Table 7. Energy Production in the Tacaagle and La Primavera“Potae Napocna” communities.

Products	La Primavera Production T/year	Production 10^3kcal	Community consumption %	Tacaagle Production T/year	Production 10^3kcal	Community consumption %
Maize	710	504,508	80	660	1,963,263	100
Sweet Potatoes	-	-	-	1,272	1,091,999	70
Vegetable(pumpkins)	8	2,223	30	127	33,658	70
Bananas	109	61,679	20	2,620	1,000,829	30
Cottonseed	250	-	-	716	-	-
Soybeans	1,489	-	-	1,201	-	-
Bovine Meat	105	241,386	10	187	451,710	50
Poultry Meat	2	3,128	100	3	4,164,911	80
Pig Meat	-	-	-	2	6,402,529	50

Data calculation base energy conversion from FAO 2007

The indigenous communities of west of Formosa province consumeabout 57,800 kcal to secure enough food for 13 family members for 3 days, at 1,500 kcal per person per dayix (Torres et al., 1998). The introduction of wheat flour has been significant, and a portion of tortilla (200g) is eaten twice a day. La Primavera has a different diet including industrial products (flour, salt, sugar, corn, yerba mate, rice, candies, oil; wild vegetables (bush pepper, carob, sweet bush, sweet bush, mistol and chaguarx); wild animals (peccary, charata, chua, iguana, lizard, fish, brush turkey, alligator and,). In addition, domesticated vegetable crops consumed are sweet potato, lime, peanuts, corn, beans, watermelon, pumpkin and domestic animals include cow, duck and pork.

3.4.3. Other relevant flows

There are other flows required for the stabilization of the metabolic pattern of these communities such biomass used for energetic purposes, fossil energy used in agriculture, electricity, drinking water and irrigation water, material for construction.

The analysis of these flows also indicates important differences between the two communities.

Consumption of biomass for energetic purposes

The estimated consumption of wood or coal for residential use was made on the basis of INDEC Census 2001, which reports the number of households using wood or charcoal for cooking. Tacaagle consumed 213 ton/year[xi] and La Primavera 1,338 ton/year. Formosa biomass extraction across native forest corresponds to 12,796 tons / year and 2,172 the cotton industry. (WISDOM/FAO, 2009)

Consumption of fossil energy in agricultural production

The community of Tacaagle has a higher degree of mechanization. 9% of traction is done by animals while mechanical traction represents 91%. La Primavera, on the other hand, is more diverse and less mechanized, with human traction representing 68%, animal traction 27% and mechanical traction just 5%.

Data on fossil energy consumption in the form of agricultural inputs are given in Table 8. We used here the coefficients calculated for another Argentinean region (Tucuman) for the year 2009 (Dilascio et al, 2009) applied to the technological coefficients calculated for our case study.

Table 8. Fossil energy input in agricultural consumption

		MJ/Ha	La Primavera MJ/Ha	Tacaagle MJ/Ha
Inputs and agrochemicals	fallow and soil preparatio	1,254	619,476	496,584
	sowing and fertilization	1,553	767,182	614,988
	crop management	1,975	975,650	782,100
	total inputs and agrochemicals	4,783	2,362,802	1,894,068
Tillage and operation	fallow and soil preparatio	100	49,202	39,442
	sowing and fertilization	368	181,792	145,728
	crop management	398	196,612	157,608
	harvest	563	278,122	222,948
	tillage and operation	1,429	705,926	565,884

Data calculated with coeficients of Dilascia *et al* , 2009

Drinking water
Drinking water is supplied through tanks, or natural water bodies (lake, river). In La Primavera 83% of the population gathers water from the lake, the wetlands or community settings and 17% of the population uses tanks. In Tacaagle the opposite occurs, with 93% of households using water tanks and only 7% natural water bodies.

Material for construction
Regarding to the use of materials for construction, there are two types of house construction. Those made from wood or palm fronds (traditional houses), and those made from concrete. La Primavera has 97% of traditional houses and only 3% concrete/brick houses, wheras in Tacaagle the concrete houses are 63% versus 37% of traditional houses.

Commuting of people
Another important flow to be considered is the flow of people to move around the fund elements of human activity. In fact this movement of people does affect the profile of allocation of human time. In regard with transportation, 77% of people from the community of Tacaagle use motorcycles and some trucks, basically to go to the grocery store and the farm, and some of them to commute to their job outside the community. Of those traveling to *chacras* or bringing children to the school: 8% use the bicycle and 15% go by foot. In the community of La Primavera 30% use the bicycle mainly to go to the grocery store that is located approximately 15km away. When they go hunting they mainly use the bicycle or the motorcycle. Children often go to school on foot and by bicycle.

However, we do not include these assessments in the comparative analysis of the metabolic pattern, carried out at the level of the whole communities, presented in the next section. These factors are more relevant when studying the characteristics of household typologies, at a lower level (they will be considered in study carried out at the household level, Arizpe et al. forthcoming)

3.5. Comparing the different metabolic patterns of the two communities

3.5.1 The characterization provided by the analysis of the metabolic pattern

In this section we use a standard representation of the metabolic pattern of a rural community, proposed by Serrano and Giampietro, (2009), that is based on the simultaneous characterization of: (i) the two fund elements "land use" and "human activity" and (ii) the two flows "monetary flows" and "food flows". These flows are associated - using the chosen taxonomy of categories - to a multi-level matrix of fund elements "land uses" and "human activities". This integrated representation of the metabolic pattern is presented in Fig. 11 and Fig. 12. In this section we present the general features of this integrated representation, in the next sections we comment the specific characteristics of the two communities.

- Characterization of the fund elements

(i) the two fund elements (Human Activity and Land Use) are represented by two pies in the middle of the figure, whereas the flows are represented by arrows indicating the interaction of the system with its context;
(ii) the pie on the left characterizes the fund element of "human activity" – its size and profile of allocation over lower level categories reflects the amount of human activity available (population) and the relative importance of societal activities in terms of requirement of human time;
(iii) the pie on the right characterizes the fund elements of "land use" – its size and profile of allocation over lower level categories reflects the amount of colonized (and semi-colonized) land available and the relevant importance of societal activities in terms of requirement of land uses;

- Characterization of the flow elements

When looking for information about the effects of the interactions that the community has with the surrounding context we have to consider the arrows entering and exiting the metabolic pattern of the rural community. In this representation these interactions are with the:
(i) Biophysical context – e.g. the semi-colonized land affected and affecting the rural system;
(ii) Economic context – e.g. the effect of socio-economic interactions outside the borders, for example the government subsidies; and
(iii) Market context – through the analysis of sales of surplus products and purchases of consumed products that are moved across the boundary to stabilize the existing metabolic pattern.

- Generation of indicators of performance

To this visual representation of the metabolic pattern we can associate a set of indicators of performance obtained by calculating various flow/fund ratios – e.g. relevant values of the density of flows (flow per hectare) and intensity of flows (flow per hour) over the two multi/level matrices of fund elements (Giampietro, 2003). That is, by using the MuSIASEM approach we can define for the farming system under analysis: (i) "what is done" – the taxonomy of categories used to describe the functions (human activities) and structures (land uses) expressed by the farming system; and (ii) "how it is done" – the characteristics of the processes (technical coefficients describing the various activities) carried out in the various activities (productivity of land, productivity of labor, economic costs, economic revenues). This information makes it possible to analyze and compare similar farming systems.

- The coupling of the socio-economic dimension to the ecological dimension

The coupling of two types of fund elements provide an important link over two dimensions of analysis: (i) when characterizing the metabolic flows against the multi-level matrix of fund elements of Human Activity we can generate information useful to study socio-economic processes (e.g. monetary cost of labor, productivity of labor, dependency ratio, opportunity cost of commuting time); (ii) when characterizing the metabolic flows against the multi-level matrix of fund elements of Colonized Land we can generate information useful to study how the pattern of societal metabolism is interfering with the metabolism of the ecosystem embedding the society and the existence of biophysical constraints to the expansion or intensification of human activity on colonized land (Giampietro et al. 2011). Put in another way, by adopting the MuSIASEM analysis we can establish a bridge between the socio-economic and the ecological dimension, making it possible an integrated analysis of different metabolic patterns across levels and scales.

- Analysis of the trade-offs between market and subsistence economy

Agricultural production (traditional, industrial, subsistence) can go either to the market to be exchanged for money (we differentiate soy from other crops-livestock) or can be consumed directly within the village, as subsistence agricultural production. In this last case we can write a virtual cash flow, equal to the monetary value, which would have been paid in the market in exchange for the subsistence good produced. From the earnings obtained selling agricultural production, one fraction can be considered net income for the people in the community, whereas another fraction must be reinvested in agricultural production, buying material inputs (e.g. fertilizers, seeds, pesticides, machinery) or energy to run the machinery (e.g. oil for tractors, electricity).

3.5.2 The analysis of the metabolic pattern of Tacaagle Community

The metabolic pattern of the Tacaagle Community is shown in Fig. 11. The break-down of the Total Human Activity of the community into different compartments (associated with functional tasks) is indicated in the left pie. Beside the human activity going into work in agriculture (cash-crops; subsistence and off-farm work) most of the human activity goes in Physiological Overhead and household chores, plus the residual of human activity going into Leisure. The break-down of the Total Colonized Land (including the semi-colonized) of the community is given in the pie on the right. Plots in Tacaagle are small, ranging from 2 to 10 hectares while in the 25 de Mayo community producers are mostly medium-sized who specialize in some type of cash crop to be sold in the regional market.

The monetary flow accounts for all earnings obtained in the community from working activities performed outside the agricultural sector or by renting out land. The combined input of monetary flows makes it possible for the community to buy goods and services from the market.

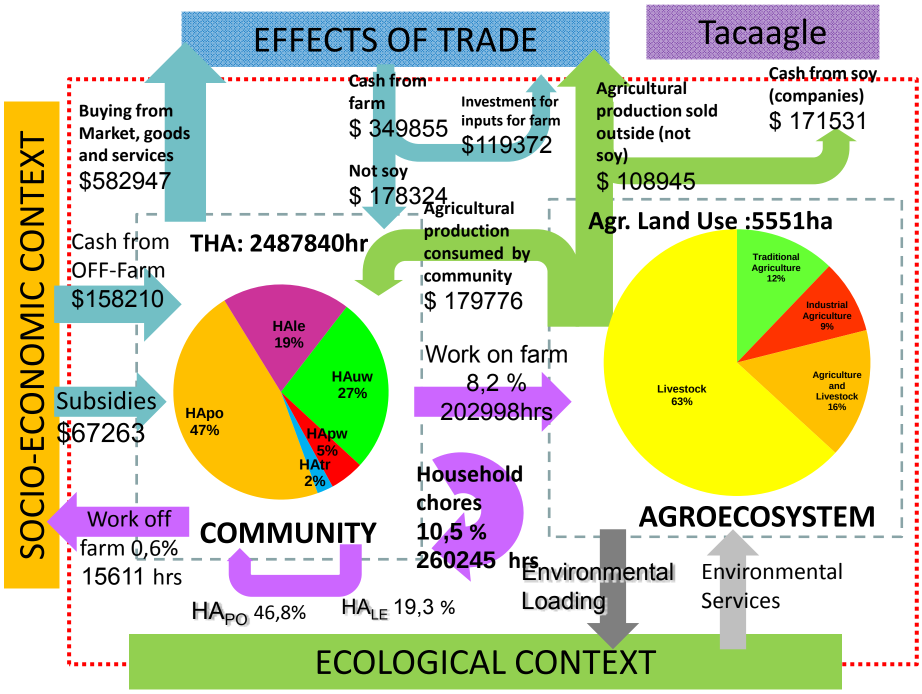


Figure 11. Metabolic Pattern of the Tacaagle community

3.5.3 The analysis of the metabolic pattern of La Primavera Community

The metabolic pattern of La Primavera a Community is shown in Figure 12. Most of the land for agriculture and livestock is generally rented. Indigenous population tends to rent the land to companies and work for them. 90% of livestock does not belong to the indigenous. They simply take care of it, on behalf of the owners, and they get wages in exchange, plus some cattle as food. This represents a large amount of cash flow, as compared to that of Tacaagle, to which significant amounts of subsidies from the government have to be added. These large amounts, however, are quite low if we compare them with the profits of soy companies. The community receives less than 10% of those profits.

Profits from the sale of agricultural production are not kept within the community La Primavera, since they only rent the land. Coming to a comparison of the allocation of Human Activity with Tacaagle, they spend less time in working on farm, which in any case is a new activity for this historically hunter-gatherer community. We can also see that an important fraction of the total earnings goes to buying goods and services from the market. The time allocated to transportation is significant because there is no access to public transport, while the communities are dispersed and 5-20 kilometres is a normal travel distance to the next market, hospital or school. The growing income, however, is increasing now the use of motorcycles or bicycles.

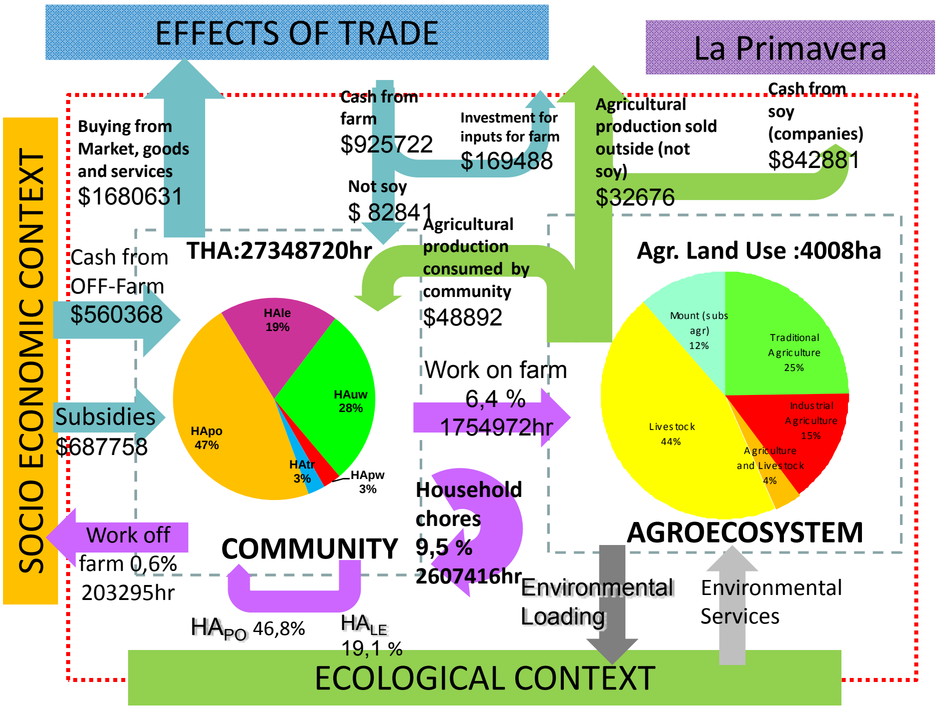


Figure 12. Metabolic Pattern of La Primavera "Potae Napocna"community

4. Discussion

The expansion of soy monocultures mainly in Argentina is affecting the livelihood of small producers who live in northern Argentina. It is important to note that in the past the province of Formosa has been developed on cultivation of cotton, which was very important in the 1970s, but has since been replaced, by other crops and livestock. Another historically important activity is livestock, which takes advantage of the natural pastures of the region. Logging has also been an important industry, which has expanded with the increase in the number of roads and associated infrastructure. Finally, the province also operates oil and gas wells in the west. From a demographic perspective, the province has been inhabited by different indigenous groups that found refuge in this "bleak" land after the desert war (that took place in 1880). It was not until 1920 that Paraguay and Argentina began to systematically colonize this area. Indigenous and criollosxii do not mix neither in social or financial terms.

These two different cultural backgrounds are reflected also in the demographic evolution of the two communities. Whereas La Primavera, home to a Qom indigenous group, who used to be nomadic just 100 years ago, shows no fast population growth and consequent crowding, reflecting an adaptation to the limited declared aboriginal reserve area, Tacaagle, settled by Paraguayan-Argentinean migrants who were mostly engaged in agriculture and livestock, shows rapid demographic growth.

The introduction and expansion of soybean production has altered the pattern of human time use in both communities. Tacaagle has seen a disassociation with the production process – landowners preferring to hire equipment or lease land. This contrasts with the attitude they used to have with respect to cotton production, where landowners were more involved and were responsible for all activities associated with production. In La Primavera this disassociation with the production process is even more pronounced as they used to be nomadic hunter-gatherers who have been confined in a protected area. As a result they just rent their land, although at a much lower price, and perform no further activity on that land. This means that their dependence on the market for sustaining their metabolism is larger, and this gets reflected in their land use.

In conclusion, the abandonment of agriculture-livestock rotation, coupled with the expansion of RRxiii soy monoculture has generated important and long-lasting changes in these two communities. When adoption an agro-ecological perspective, one could say that the soybean monoculture is a critical path away from environmental sustainability. The large scale development of corporate farming is based on the availability of external resources to invest in inputs and technology, and this development has altered the traditional relation of owners/producers with land, highlighting the figure of the tenant in the region, although with varied contractual arrangements (Albanesi et al., 2003).

Changes in relative prices, in particular, the recent increase in the price of soy, plus unfavorable economic policies have led to the disappearance of small and medium-size farmers and to the concentration of land and economic power in the region (Azcuy y León, 2005). When assessing the economic result of this change at the large scale, we can perceive this change as a positive economic growth for the region, meaning a larger flow of added value (monetary flow) per capita. However, when characterizing these changes in a multi-scale integrated analysis we can easily detect that this larger monetary flow does not reach households or rural communities, as it remains concentrated in the hands of tenants producing soy. Therefore, the monoculture expansion generates more monetary flows for urban elites, but supports fewer rural households. This cannot be considered a desirable development path for the rural communities analyzed here.

5. Conclusions

In this paper we tested the usefulness of the MuSIASEM as an integrated analysis tool to understand the effect of changes induced by the expansion of soy monuculture over two rural communities operating in the North of Argentina.

Our preliminary results show that MuSIASEM can be used to establish a bridge between different dimensions of analysis (interfacing socio-economic variables with ecological and biophysical variables) and different scales of analysis (the local-scale characterization of households and communities can be related to variables and benchmarks referring to Regional or National analysis).

This multi-level analysis is also crucial since it makes it possible to effectively use the information generated using participatory methodologies for better understanding of the dynamics and complexity in the communities. The information generated in this way can be used to make it possible an informed deliberation, within local communities, over the pros and cons of soy expansion. In fact, information and communication technologies can be used to enhance the effectiveness of participatory processes for community capacity building. When local communities can generate (and be in control of) their own information – that is, when they can record such an information in the form of data referring to relevant categories, maps, pictures and videos, they can enrich the discussion over possible sustainable paths because their cultural diversity can be translated in a more effective perception of relevant issues to be considered. In this case study, for example, we found two communities operating within the same region, but totally different in cultural aspects and still expressing similar land uses.

Another important aspect of multi-level analysis is that it makes it possible to individuate the relations that flows have with fund elements at different scales and level of analysis. For example, soy monocultures certainly boost the monetary flows associated with an hectare of colonized land. However, when looking at the metabolic pattern of the community we can clearly see that the larger cash flow does not remain with (= it is not spent by) the rural communities.

In conclusion multi-scale integrated analysis of the metabolic pattern of rural communities provides a useful representation of the sustainability predicament by providing a holistic vision of the various aspects (dimensions of analysis) and perceptions of the various social actors (socio-economic units reproducing at different hierarchical levels). In our view this richer representation can help a better informed discussion over policies more suited to the needs of communities.

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7. References

AAPRESID, 2008. Agribusiness: Production, Sustainability and Environment. Argentine Association of No-Till Farmers. Rosario, Argentina.

Albanesi, R., Gonzalez, C, Preda, G., 2003. Transformaciones en la agricultura santafesina. La importancia de los contratistas de producción. En: Actas IV Jornadas Interdisciplinarias de Estudios Agrarios y Agro - industriales. FCE -. UBA. Buenos Aires.

Altieri, M., 2009. The ecological impacts of large-scale agrofuel monoculture production systems in the Americas. Bulletin of Science, Technology and Society 29, 236–244.

Azcuy, A., E., and León C., 2005. La sojización: contradicciones, intereses y debates. Revista Interdisciplinaria de Estudios Agrarios, 2005, N° 23, p. 133-158.

Binimelis, R., Pengue, W., Monterroso, I., 2009. “Transgenic treadmill”: Responses to the emergence and spread of glyphosate-resistant johnsongrass in Argentina. Geoforum, pp. 623-633.

Blanco, 2009. Naturaleza y Región Pampeana. La agricultura conservacionista en productores familiares y empresariales de la región Pampeana. En: Morello J.H. and Rodriguez, A.F., 2009. El Chaco sin bosques. 1a ed. - Buenos Aires: Orientación Gráfica Editora, 432 p. Boletta, P.E., Ravelo, A.C., Planchuelo, A.M., Grilli, M., 2006. Assessing deforestation in the Argentine Chaco. Forest Ecology and Management 228, 108-114.

Bryman, A., 2008 Social Research Methods. Oxford University Press, 748 p.

CIA, 2009. The World. Central Inteligence Agency Fact book. Argentina. https://www.cia.gov/library/publications/the-worldfactbook/print/ar.html.

Domínguez, D. y Sabatino, P., 2006. Con la soja al cuello: crónica de un país hambriento productor de divisas" in Alimonda, H., (comp.) Los tormentos de la materia, aportes para una ecología política latinoamericana.Buenos Aires. CLACSO. pp 1-74.

Dilascio, M. P. , Caro, R.F., Scandaliaris J., Abascal F., Paz D., Cárdenas G. J., Diez O. A., y Romero E., 2009. Balance Energético del Cultivo de Soja como Fuente para la Obtención de Biodiesel en Tucumán, Argentina . Revista Brasileña de Agroecologianov. 2009 Vol. 4 No. 2.

Eisenmenger, N., Ramos-Martin, J., and Schandl, H., 2007. Transition in a changed context: patterns of development in a globalizing world, Fischer-Kowalski, M., Haberl, H., Editors. Socioecological Transitions and Global Change: Trajectories of Social Metabolism and Land Use, Edward Elgar, Cheltenham Editor, pp. 179–222.

EPRASOL., 2008. Territorio Indigena: Situación, usos, problemas y propuestas. EPRASOL. Las Lomitas, Formosa. pp 24.

FAO, 2007. Food and Agricultural Organisation Statistics: Energy Balance. FAO, Rome, http://faostat.fao.org/site/354/default.aspx

FAO, 2010. Food and Agriculture Organization of the United Nations (FAO). 2009. Food Price Indices. http://coin.fao.org/cms/world/argentina/es/InformaccionSobreElPais.html?

Falconi-Benitez, F., 2001. Integrated assessment of the recent economic history of Ecuador, Population and Environment 22 (3): 257-280.

FIDA., 2009. Cartographie participative et bonnes pratiques. Étude préparée pour le Fonds international de développement agricole. Rome Italie pp. 55

García-López, G.A., Arizpe, N., 2010. Participatory processes in the soy conflicts in Paraguay and Argentina. Ecological Economics 70, 196-206.

Gasparatos, A., El-Haram, M., Horner, M., 2009. Assessing the sustainability of the UK society using thermodynamic concepts: Part 1. Renewable and Sustainable Energy Reviews 13, 1074-1081.

Gasparri, N.I., Grau, H.R., 2009. Deforestation and fragmentation of Chaco dry forest in NW Argentina (1972–2007). Forest Ecology and Management 258, 913-921.

Georgescu-Roegen, N., 1971. The Entropy Law and the Economic Process, Harvard University Press, Cambridge, MA.

Georgescu-Roegen N. Energy and economic myths. Southern Economic Journal 1975;41: 347–81.

Georgescu-Roegen, N., 1977. Matter matters, too, K.D. Wilson, Editor, Prospects for Growth: Expectations for the Future, Praeger, New York (1977), pp. 293–313.

Giampietro, M., Allen, TFH., Mayumi, K., 2006a. Science for governance: the implications of the complexity revolution. In: Guimaraes-Pereira A, Guedes-Vaz S, Tognetti S, editors. Interfaces between science and society. Sheffield: Greenleaf Publishing; p. 82–99.

Giampietro, M., Allen, T.F.H., Mayumi, K., 2006b. The epistemological predicament associated with purposive quantitative analysis. Ecological Complexity 3, 307-327.

Giampietro, M., Mayumi, K., 1997. A dynamic model of socioeconomic systems based on hierarchy theory and its application to sustainability. Structural Change and Economic Dynamics 8, 453-469.

Giampietro, M., Mayumi, K., 2000a. Multiple-scale integrated assessment of societal metabolism: introducing the approach. Popul Environ Vol. 22(2): 109–53.

Giampietro, M., Mayumi, K., 2000b. Multiple-scale integrated assessment of societal metabolism: integrating biophysical and economic representations across scales. Popul Environ Vol. 22(2):155–210.

Giampietro, M., Mayumi, K., Munda, G., 2006c. Integrated assessment and energy analysis: Quality assurance in multi-criteria analysis of sustainability. Energy 31, 59-86.

Giampietro, M., Mayumi, K., Ramos-Martin, J., 2009. Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM): Theoretical concepts and basic rationale. Energy 34, 313-322.

Giampietro, M., Pimentel, D., 1990. Assessment of the energetics of human labor. Agriculture, Ecosystems & Environment 32, 257-272.

Giampietro, M., 1997. Socioeconomic constraints to farming with biodiversity. Agriculture, Ecosystems & Environment 62, 145-167.

Gomiero, T., and Giampietro, M., 2001. Multiple-scale integrated analysis of farming systems. The Thuong Lo commune (Vietnamese uplands) case study. Population and Environment 22 (3): 315 -352.

Grau, H. R., and M. Aide, 2008. Globalization and land-use transitions in Latin America. Ecology and Society 13(2): 16. [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art16/

Grau, H. R., Gasparri N. I., and Aide T. M.. 2005. Agriculture expansion and deforestation in seasonally dry forests of northwest Argentina. Environmental Conservation 32:140–148.

Grünbühel, C.M., Haberl, H., Schandl, H. and Winiwarter, V., 2003. Socio-economic metabolism and colonisation of natural processes in Sang Saeng village: material and energy flows, land use and cultural change in Northeast Thailand, Human Ecology, Vol. 31, No. 1, pp.53–85.

Grünbühel, C., Schandl, H., 2005. Using land-time-budgets to analyse farming systems and poverty alleviation policies in the LAO PDR, International Journal of Global Environmental Issues, Vol. 5 (3/4): 142-180.

IADB Garten Rothkopf, 2007. A Blueprint for Green Energy in the Americas. Strategic Analysis of Opportunities for Brazil and the Hemisphere. Featuring: The Global Biofuels Outlook 2007 Prepared for the Inter-American Development Bank by Garten. Inter American Development Bank, Washington, DC. Pp 53

INDEC, 2001 INDEC. Censo Nacional de Población, Hogares y Viviendas 1991 y 2001.[INDEC, 2001 INDEC. National Census of Population and Housing 1991 and 2001.]

Iñigo, V. 2008. Sujetos productivos, sujetos políticos, sujeto indígena: las formas de su objetivación mercantil entre los tobas del Este de Formosa. Tesis doctoral Facultad de Filosofia y Letras, Universidad de Buenos Aires.

Iorgulescu, R. I. and Albu, L.L., 2009 Technical Report, SMILE_The Case of Romania (MuSIASEM Variables and Energy Intensity in Four Central and Eastern European Countries: MuSIASEM Hierarchical Analysis down to level n-4. Estimating Hidden Economy and Hidden Migration), Toolkit Workshop, Aboyne, Scotland (June 9-12, 2009). European Commission.

Kauffman, S.A., 1993. The origins of order. New York: Oxford University Press.

Lotka, A. J., 1956. Elements of mathematical Biology. Dover Publications. New York

Mathews, J.A., Goldsztein, H., 2009. Capturing latecomer advantages in the adoption of biofuels: The case of Argentina. Energy Policy 37, 326-337.

MSyA and UNEP, 2004. GEO Argentina: Perspectivas del medio ambiente. Ministerio de Salud y Ambiente de la Nacio´n (MSyA) Argentina and United Nations Environment Programme (UNEP). /www.ambiente.gov.ar/archivos/ web/GEO/File/Geo_Argentina_2004.pdfS. [MSyA, and UNEP, 2004. GEO Argentina: Environment Outlook. Ministry of Health and Environment Nacio'n (MSyA) Argentina and United Nations Environment Programme (UNEP). / www.ambiente.gov.ar/archivos/ web/GEO/File/Geo_Argentina_2004.pdfS.]

Ministerio del Interior, 2011. Portal Oficial del Gobierno de la Provincia de Formosa.

Monti, M., 2008a. Impacto en el sector productivo por el aumento en los Derechos de Exportación en Soja. Dirección de Extensión e Investigación Agropecuaria, Ministerio de la Producción, Provincia de Santa Fé, Argentina.

Monti, M., 2008b. Retenciones móviles en los granos: impactos económicos en el Distrito de Rufino. Dirección de Extensión e Investigación Agropecuaria, Ministerio de la Producción, Provincia de Santa Fé, Argentina.

Morello, J.; Rodriguez A. y Pengue W., 2006. Mirando al revés: la ciudad desde el campo. El caso de la llanura chaco-pampeana argentina. En: Brown, A.; U. Ortiz; M. Acerbi y J. Corcuera (Eds.)La situación ambiental argentina 2005. Fundación Vida Silvestre Argentina. PP: 447-455.

Morello J.H. y Rodriguez, A.F., 2009. El Chaco sin bosques / edición literaria a cargo de Jorge H. Morello y Andrea F. Rodríguez. 1a ed. - Buenos Aires : Orientación Gráfica Editora, 432 p. ISBN 978-987-9260-73-9

Morowitz, HJ.,1979. Energy flow in biology. Woodbridge: Ox Bow Press.

Naumann, M., y Madariaga, M., 2003. Atlas Argentino/Agentinienatlas, Programa de Acción Nacional de Lucha contra la Desertificación, Secretaría de Ambiente y Desarrollo Sustentable, Instituto Nacional de Tecnología Agropecuaria, Deutsche Gesellschaft für Technische Zusammenarbeit, Buenos Aires. 94 p.
Negri, R., 2008. Argentine Management and the 'Pampas Revolution'. Consorcios Regionales de Experimentación Agrícola (CREA), BuenosAires.

NOAA, 2009. Stakeholder Engagement Strategies for Participatory Mapping. Coastal Services Center. USA

Odum, H.T., 1971. Environment, power, and society. New York: Wiley-Interscience.

Odum, H.T., 1983. Systems ecology. New York: Wiley.

Odum, H.T., 1996. Environmental accounting: emergy and decision making. New York: Wiley.

Pastore, G., Giampietro, M. and Ji, L., 1999. 'Conventional and land-time budget analysis of rural villages in Hubei province, China', Critical Reviews in Plant Sciences, Vol. 18, No. 3, pp.331–358.

Pengue, W., 2005. Transgenic crops in Argentina: The ecological and social debt. Bulletin of Science, Technology & Society, 25, 314-322.

Pengue W. A., 2009a. El Desarrollo Rural Sostenible y los procesos de agriculturización, ganaderización y pampenización en la llanura Chaco-Pampeana. En: Morello J.H. and Pengue,
W.A., 2009. Fundamentos de Economía Ecológica. Bases teóricas e instrumentos para la resolución de los confl ictos sociedad naturaleza Editorial Kaicron. Buenos Aires.

Pengue, W.A., 2009b. Se está perdiendo la Soberanía Alimentaria de los Pueblos. Entrevista. Diario Página 12. Buenos Aires. Febrero 2. 2009. [Translation: Pengue W.A., 2009b. It is losing the People's Food Sovereignty. Interview. Journal page 12. Buenos Aires. February 2. 2009.]

Qaim M. and Traxler G., 2005. Roundup ready soybeans in Argentina: farm level and aggregate welfare effects, Agricultural Economics 31 (1) (2005), pp. 73–86.

Ramos-Martin, J., 2001. 'Historical Analysis of Energy Intensity of Spain: From a "Conventional View" to an "Integrated Assessment"', Population and Environment, 22(3), 281-313.

Ramos-Martin, J., 2005. Complex Systems And Exosomatic Energy Metabolism Of Human Societies, PhD, Autonomous university of Barcelona.

Ramos-Martin, J., Giampietro, M., Mayumi, K., 2007. On China's exosomatic energy metabolism: An application of multi-scale integrated analysis of societal metabolism (MSIASM). Ecological Economics 63, 174-191.

Ramos-Martin J., Cañellas-Boltà S., Giampietro M. and Gamboa G., 2009, Catalonia's energy metabolism: Using the MuSIASEM approach at different scales. Energy Policy, Volume 37 (11): 4658-4671.

Recalde, M., Ramos-Martin, J., 2011. Going beyond energy intensity to understand the energy metabolism of nations: The case of Argentina. Energy, in press, doi:10.1016/j.energy.2011.07.011

Rosen, R., 1958. The representation of biological systems from the standpoint of the theory of categories. Bull Math Biophys Vol. 20:317–41.

Rosen. R., 2000. Essays on life itself. New York: Columbia University Press.

Rusell, B., 2009. Social Research Methods: Qualitative and Quantitative Approaches. SAGE Publications, Inc USA ISBN: 9780761914037

Serrano, T., Giampietro, M., 2009. A multi-purpose grammar generating a multi-scale integrated analysis in Laos, Reports on Environmental Sciences, num. 3, Instituto de Ciencia y Tecnología Ambientales. Universidad Autónoma de Barcelona. http://www.recercat.net/handle/2072/16100

Tomei J. and Upham P., 2009. Argentinean soy-based biodiesel: An introduction to production and impacts Energy Policy 37 pp. 3890–3898

Torres G., Santoni M., de Zito-Fontán L., Romero L. and Barbarán F., 1998. Alimentacion y Nutrición de los Mataco del Pilcomayo. Un estudio Antropológico. Revista Andes Nº10 CEPIHA Universidad Nacional de Salta. [Torres G., Santoni M., Zito, Fontan L., L. Romero and Barbara F., 1998. Food and Nutrition Mataco Pilcomayo. An anthropological study. Journal No. 10 CEPIHA Andes Universidad Nacional de Salta.]

Ulanowicz, R.E., 1986. Growth and development: ecosystem phenomenology. New York: Springer

Ulanowicz, RE., 1995. Ecosystem integrity: a causal necessity. In: Westra L, Lemons J, editors. Perspectives on ecological integrity. Dordrecht: Kluwer Academic Publishers; p. 77–87.

WISDOM Argentina, FAO., 2009. Análisis del Balance de Energía derivada de Biomasa en Argentina. Informe Técnico FinalWISDOM Argentina [Translation: WISDOM Argentina, FAO., 2009. Analysis of the Balance of Energy from Biomass in Argentina. Technical Report FinalWISDOM Argentina]

Zak, M. Cabido, D. Caceres and S. Diaz, 2008 What drives accelerated land cover change in central Argentina? Synergistic consequences of climatic, socioeconomic and technological factors, Environmental Management 42 (2008), pp. 181–189.

Zak, M.R., Cabido, M., Hodgson, J.G., 2004. Do subtropical seasonal forests in the Gran Chaco, Argentina, have a future? Biol. Conserv. 120, 589–598

Zipf , G.K., 1941. National unity and disunity: the nation as a bio-social organism. Bloomington: The Principia Press.

8. Foot notes

[i] Businessmen, farmers or agronomists, who set up a financial pool to capture resources for leasing fields, purchasing inputs and hiring third-party services to reduce costs, increasing production scale and reducing environmental and climatic risks in agricultural production (Pengue, 2009a)). They are investment companies which bring together landowners, contractors and technicians for soybean production and favor capital concentration in the hands of large contractors that lease the land from small and medium landholders (Binimelis et al., 2009).
[ii] *Argentina does not officially use the term 'indigenous', but rather 'aboriginal' population. We use the term indigenous, which is more frequent in Latin America.*
[iii] *It is a rural area where agriculture and / or livestock is practiced, whether it is minor or major.*
[iv] *The small producers have less than 10 hectares.*
[v] *Every defined area has in general one property that could be one extended family (meaning two or more households).*
[vi] *It is a cultural drink.*
[vii] *The distribution considers an urban area in the centre and the chacras around this area.*
[viii] *Activities mainly related to women's roles such as caring of children, preparing food, cleaning the house*
[ix] The Qom's do not eat every day because their consumption historically is based in gathering-hunting. But the modifications of their consumption are also in dependence of the available food.
[x] *This plant is used for handicraft.*
[xi] *We consider three Tons per year in rural areas (Wisdom/FAO, 2009) and biomass similar to charcoal.*
[xii] *The indigenous called criollos to the inhabitants that colonized their land.*
[xiii] *Roundup Ready Soybeans. The Roundup Ready® seeds contain in-plant tolerance to Roundup® agricultural herbicides, allowing growers to spray Roundup agricultural herbicides to kill the weeds without harming the crop.*